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The Effect of Binary Interactions in Infrared Passbands

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Abstract. We present the integrated J, H, K, L, M and N magnitudes and the colours involving infrared bands, for an extensive set of instantaneous-burst binary stellar populations (BSPs) by using evolutionary population synthesis (EPS). By comparing the results for BSPs *WITH* and *WITHOUT* binary interactions we show that the inclusion of binary interactions makes the magnitudes of populations larger (fainter) and the integrated colours smaller (bluer) for $\tau \geqslant 1\,\mathrm{Gyr}$. Also, we compare our model magnitudes and colours with those of Bruzual & Charlot (2003, hereafter BC03) and Maraston (2005, hereafter M05). At last, we compare these model broad colours with Magellanic Clouds globular clusters (GCs) and Milky Way GCs. In $(V-R)-$[Fe/H] and $(V-I)-$[Fe/H] diagrams it seems that our models match the observations better than those of BC03 and M05.

Keywords. infrared: general, binaries: general, stars: evolution, galaxies: clusters: general.

Introduction In previous paper (Zhang et al. 2005) we took into account binary interactions (BIs) in evolutionary population synthesis (EPS) models, presented the integrated $U-B$, $B-V$, $V-R$ and $V-I$ colours of binary stellar populations (BSPs), while did not give the infrared magnitudes and colours because larger fluctuations exist. However, these results in infrared passbands are very important in EPS models because the infrared light can reflect the metallicity of populations and the visible/infrared colours are the candidates of breaking the degeneration between age and metallicity.

Results We present the infrared integrated magnitudes and colours for BSPs. The ages of BSPs are in the range 1-15 Gyr, the metallicities are in the range $0.0001 - 0.03$.

In Fig. 1 we present the bolometric magnitude M_{BOL}, K magnitude, $B-V$ and $V-K$ colours at $Z = 0.02, 0.004$ and 0.0001 for BSPs *WITH* and *WITHOUT* BIs, the results of Bruzual & Charlot (2003, hereafter BC03) using Salpeter (1955, hereafter BC03-S) and Chabrier (2003, hereafter BC03-C) IMFs, the results of Maraston (2005, hereafter M05) using Salpeter (1955, hereafter M05-S) and Kroupa (2001, hereafter M05-K) IMFs, and the recent $V-K$ of Bruzual (2007, hereafter B07) at solar metallicity. By comparison we see that **(i)** the magnitudes and colours of BSPs *WITH* BIs are greater (fainter) and smaller (bluer) than those *WITHOUT* BIs, respectively. **(ii)** The magnitudes of BC03-S, BC03-C, M05-S and M05-K are greater than ours. **(iii)** The shape of the evolutionary curves of these colours is significantly different. In Fig. 2 we compare the model colours with Magellanic Clouds globular clusters (GCs) with the type of Searle, Wilkinson & Bagnuolo(1980, hereafter SWB) in the range of 3-7 and the young star clusters in the merger remnant galaxy NGC 7252 in $(B-V)$.vs.$(U-B)$ and $(B-V)$.vs.$(V-K)$ diagrams. It shows that the BC03 and our models agree with the observations in $(B-V)$.vs.$(U-B)$ diagram; while in $(B-V)$.vs.$(V-K)$ diagram larger discrepancies exist among models. In Fig. 3 we compare the model broad colours with Milky Way GCs in colour-metallicity

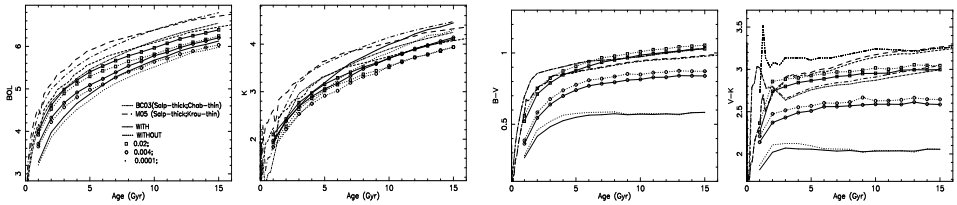

Figure 1. The bolometric magnitude ($M_{\rm BOL}$), K magnitude, $B-V$ and $V-K$ colours for BSPs *WITH* and *WITHOUT* BIs at $Z = 0.02$, 0.04 and 0.0001. Also shown are the results of BC03-S, BC03-C, M05-S and M05-K at solar metallicity. In $V-K$ diagram the recent results of B07 are shown (dash-dot-dot-dot).

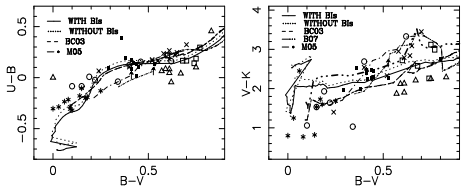

Figure 2. $B-V$ versus $U-B$, $B-V$ versus $V-K$ colours of star clusters. The different symbols represent Magellanic Clouds GCs with the SWB type in the range 3-7. Solid rectangles show the young star clusters in the merger remnant galaxy NGC 7252. The full and dotted lines show the evolution of BSPs *WITH* and *WITHOUT* BIs at $Z = 0.01$, the ages of BSPs are greater than a few Myr. The dashed lines are the BC03-S (thick) and BC03-C (thin) models at $Z = 0.008$, the dot-dash lines are the M05-S (thick) and M05-K (thin) models at $Z = 0.01$ with age $\log\tau > 8$ yr, respectively. In $V-K$ diagram the values of B07 at solar metallicity are also shown (dash-dot-dot-dot).

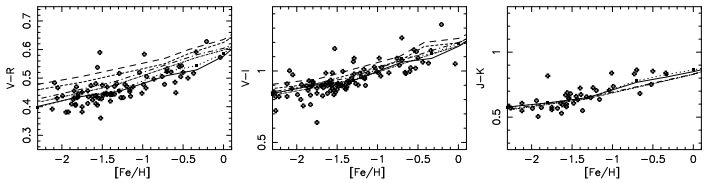

Figure 3. Comparison of colours with data of Milky Way GCs. The lines represent the same models as in Fig. 2. All models have the same age $\tau = 13\,$Gyr

diagrams. It shows that our models match the observations better than M05 and BC03 in $(V-R)$-[Fe/H] and $(V-I)$-[Fe/H] diagrams.

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References

Bruzual, G.A. 2007, *IAUs, Stellar populations as Building Blocks of Galaxies* 241, 125 **(B07)**
Bruzual, G.A. & Charlot, S. 2003, *MNRAS* 344, 1000 **(BC03)**
Chabrier, G. 2003, *PASP* 115, 763
Kroupa, P. 2001, *MNRAS* 322, 231
Maraston, C. 2005, *MNRAS* 362, 799 **(M05)**
Salpeter, E.E. 1955, *ApJ* 121, 161
Searale, L., Wilkinson, A. & Bagnuolo, W.G. 1980, *ApJ* 239, 803
Zhang, F., Han, Z., Li, L. & Hurley, J.R. 2005, *MNRAS* 357, 1088